TENACITY OF LIFE IN ANTS.

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MAIMED ANTS.

Remarkable tenacity of life is sometimes exhibited by ants lacking a portion of the body.

A queen, *Stenamma fulvum piceum*, deprived of the funicles of her antennæ, lived fourteen months in one of my artificial nests, where she laid eggs, sought her own food, and received kindly treatment from the resident workers and several unmutilated queens.

The head of a *Formica fusca subsericea* worker under my observation, continued to move its antennæ seven hours after decapitation.

Ants lacking a leg or two may live several weeks. A *Stenamma fulvum* worker, deprived of its mesothoracic pair of legs, was returned by me to an artificial nest where were hundreds of its former comrades and it safely lived there a month or more, disproving any general assertion that ants destroy maimed members of their colony.

Worker ants deprived of the abdomen sometimes run with great speed, continue to care for the young in the nest, fight with aliens of their own or other species, and they may for some days behave as if unconscious of loss. A *Stenamma fulvum* queen deprived of her abdomen lived thereafter for fourteen days in one of my artificial nests, and was seen to eat. A *Formica subsericea* worker lived without her abdomen for five days.

M. Charles Janet mentions [1] an ant that lived nineteen days after decapitation. In experiments made by me, headless ants have continued to walk about for many days. In all these experiments aseptic surgery was attempted, the instruments used being carefully sterilized. The Petri cells in which the maimed ants were

[1] "*Extrait des Compte rèndus hebdomadaires des Séance de l' Académie des Sciences*," Paris, 11 juillet, 1898, p. 130.

kept were frequently cleansed with 80 per cent. alcohol, and only distilled water was used in wetting the enclosed sponges. Care was taken to maintain hygienic conditions at all times during the life of the ant. In these experiments a *Stenamma fulvum* worker lived ten days without her head. A *Formica subsericea* worker lived fifteen days without her head. Of seven decapitated *Camponotus pennsylvanicus* workers, three lived five days; two lived twenty-one days; one lived thirty days; and one lived forty-one days. The last two mentioned were the largest, being thirteen millimeters long. After decapitation, they were kept for four days at a temperature of about 10° C. or 50° F. and afterward in the natural summer temperature of the laboratory.[1] The ant that lived forty-one days after decapitation walked about in the cell until two days before her death, and during the last two days gave evidence of life by a twitching of the legs when I touched her.

SUBMERGENCE.

While making experiments in June, 1904, with a view to ascertaining how long ants could live under water,[2] I came to suspect that the death of ants submerged less than seventy-two hours was caused by bacteria rather than by deprivation of oxygen. Later in the summer I therefore made further experiments, merging the ants in distilled water, and keeping them in the dark at a temperature of about 10° C. or 50° F. Under these conditions the ants survived much longer periods of submergence.

Of eighteen *Stenamma fulvum* submerged four days, seventeen revived and twelve fully recovered.

Of fourteen *Stenamma fulvum* submerged six days, six revived, and one fully recovered.

Of twelve *Stenamma fulvum* submerged eight days in sixty-five cubic centimeters of water, seven revived and fully recovered.

Of seven *Camponotus pennsylvanicus* submerged eight days, four revived, fully recovered, and were returned to their old associates.

[1] Nearly all the experiments recorded in this paper were made at the Marine Biological Laboratory at Woods Holl, Mass., during the summer and autumn of 1904.

[2] "Observations on Ants in their Relation to Temperature and to Submergence," A. M. Fielde, BIOLOGICAL BULLETIN, Vol. VII., No. 3, August, 1904, p. 170.

The ants recovering after submergence were those of large stature among their kind.

Dwarf Ants.

The ability of the larva to successfully enter the pupal-stage of development at any time after about half its normal size has been attained, helps to assure the persistence of a harried community. Under propitious conditions the larva grows to the size of an adult ant, expels the contents of the alimentary canal, and eats nothing during the five or ten days preceding pupation. But if suddenly deprived of food it may enter the resting stage when half-grown and may ultimately become a perfectly formed dwarf. I sequestered many fat, healthy, half-grown larvæ of *Stenamma fulvum*, put them in the care of fewer nurses than could regurgitate food to all of them, and supplied but little nutriment to the segregated group. Many of the larvæ soon entered the resting stage and later on became dwarf workers, only three or four millimeters in length, while the length of workers of their species is usually from five or seven millimeters. A corresponding diminution in the stature of a man would take from one to two feet from his height. The dwarf workers were wholly normal in their faculties and activities, and were markedly assiduous in their care of the young. On the other hand, larvæ poorly fed may miserably linger, as if waiting for better times. In one case under my observation, an ill fed larva remained such for one hundred and forty days, although constantly in summer temperature, and it then died without pupating.

Deprivation of Food.

Although ants manifestly suffer and soon die if deprived of water, they can exist for many days without food. In the following tests the ants were kept in Petri cells, ten centimeters in diameter, and not more than five ants were enclosed in any one cell. All the cells were kept in darkness or very dim light. At intervals, never exceeding four days, the cells and the enclosed sponges were cleansed with 80 per cent. alcohol, to prevent microscopic growths which might furnish nourishment to the ants. The cells contained only the ants used in the experiment, and a

to live without food, enhances their value in slavery, where other species so often hold them.

Of two *Camponotus castaneus americanus* workers,[1] measuring thirteen millimeters, one lived fifty-four days, and the other lived more than a hundred days.

Two winged queens of *Camponotus americanus*, eighteen millimeters in length, and at least three months old, were established in a separate cell on July 13. One of them dropped her wings on July 31, while the other continued to wear her wings. No eggs were laid by either and both were alive on October 18.

Elimination of Inedible Substances.

The skill with which ants eliminate from their food supply such inedible substances as may be commingled therewith, was shown in the action of *Stenamma fulvum piceum* toward certain dye-stuffs that I mixed with their nutriment. Into each of four similar Fielde nests, C, I, T, and M, I put one queen and fifty workers, with a few half-grown larvæ. During three months no food was given to these ants other than what is hereinafter mentioned. The dye-stuffs were first triturated, molasses was added to make with them a thick paste, and a portion of the paste was then placed in the food-room of the nest. For the C nest, cochineal was commingled with the molasses; for the I nest, indigo; and for the T nest, tumeric; while for the M nest, molasses alone was provided. During the three months hardly any ants died in either nest. There was no evidence that any larva was devoured; and as the introduced larvæ appeared in due time in active life, they must have been nourished solely upon regurgitated food. In only one of the nests were any eggs seen, their absence probably being due to deprivation of insect food.

In all of the nests the finely pulverized inedible substances mixed with the molasses were separated in the mouths of the ants from the nutrient fluid, and were cast out in minute pellets, forming a characteristically colored heap in a corner of each nest, C, I, and T. In the M nest, a smaller pile of brown pellets indicated that non-nutritious particles had been rejected from the unmixed molasses.

[1] These ants were kindly identified for me by Dr. W. M. Wheeler.

bit of sponge saturated with distilled water. Care was taken to ensure good ventilation and all other conditions were made hygienic, that there might be no cause of death other than that of deprivation of food. The starving ants did not manifestly weaken after long abstinence but collapsed suddenly and finally, giving no premonitory evidences of exhaustion.

Of thirty *Cremastogaster lineolata*, segregated on July 2, 1904, ten lived so long as ten days and only one lived so long as eighteen days without food.

Of thirteen *Camponotus herculeanus pictus* workers, two lived seven days; two, fourteen days; one, eighteen days; one, twenty-three days; two, twenty-four days; one, twenty-six days; and one, twenty-nine days. On the tenth day of fasting, I found three of these ants killed and dismembered, with an appearance of having been chewed. In all the cells, this was the only group where the ants attacked their companions in tribulation. As ants sometimes quarrel with their mates when food is plentiful, this affray cannot be fairly attributed to a cannibalistic tendency in this species.

Of nine *Stenamma fulvum* workers, two lived eighteen days; one, twenty-seven days; one, twenty-nine days; one, thirty-two days; two, thirty-six days; one, thirty-eight days; and one, forty-six days. The last to die measured seven millimeters.

Of eight *Camponotus pennsylvanicus* workers, one lived fourteen days; two, eighteen days; one, twenty-one days; one, twenty-two days; one, thirty-nine days; one, forty-five days, and one, forty-seven days. The last two mentioned were fourteen millimeters long, and were larger than any of those that died earlier.

Of five *Formica lasiodes* workers, one lived ten days; two, eighteen days; one, thirty-nine days. An isolated queen of this species, lived from July 2 to August 31, just sixty days. During her isolation, she deposited seven eggs, the seventh being laid on the twenty-first day of her fasting. Any egg discovered in the cell was at once removed.

Of nine *Formica fusca subsericea* workers, picked up from a roadside and segregated without feeding on July 3, one lived ten days; one, seventy-one days; and the other seven were all alive on October 18. Possibly the remarkable capability of these ants

Such preclusion of innutrient matter from the alimentary canal must greatly conserve the physical energy of the ants in the processes of digestion.

Avoidance of Poisons.

Ants that had fasted ten days did not partake of sweets in which poisons were incorporated, although their equally hungry mates ate the unpoisoned sweets with avidity.

When the ants were compelled to walk over a mixture of one gram of corrosive sublimate with two cubic centimeters of molasses, they afterward cleaned their feet with tongue and mandibles, and then evinced much distress in cleaning their mouths, but nearly all of them survived the experience.

When one gram of potassium cyanide was dissolved in five cubic centimeters of molasses, and the ants compelled to walk upon the solution, they appeared to die within a few seconds after touching the feet with the tongue, but they all revived some minutes or hours later and continued their normal activities.

When one gram of carbolic acid crystals was dissolved in two cubic centimeters of molasses, the ants compelled to walk upon the solution cleaned their feet with their tongues and mandibles, evinced much distress, and died after some hours or days, with no subsequent resuscitation.

In the experiments with poisons, the ants employed were *Cremastogoster lineolata*, *Stenamma fulvum*, *Lasius latipes*, *Formica subsericea*, *Camponotus pennsylvanicus* and *Camponotus castaneus americanus*. In these experiments the largest ants were latest in succumbing to the effects of the administered poisons. *Camponotus americanus*, about thirteen millimeters in length, lived several days after the administration of the carbolic acid, and in a natural environment might possibly have remedied their ills.

Regurgitation of Food.

Whether the regurgitation of food be a simple reflex or an altruistic act, it was practiced by some of the ants when there was little to confer upon a starving comrade. One *Camponotus pennsylvanicus* worker was seen to make unsuccessful effort to regurgitate food to another on the thirty-first, and also on the thirty-sixth day of fasting.

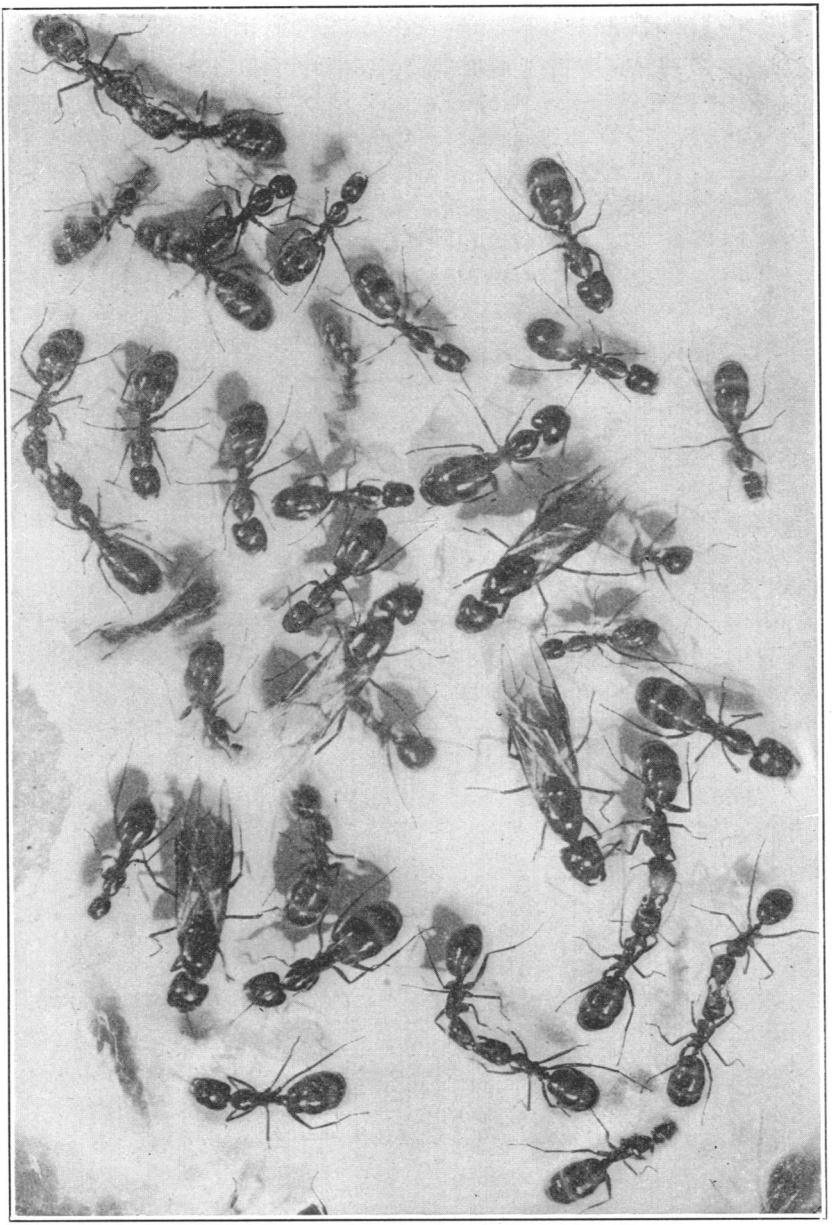

FIG. 2. *Camponotus castaneus americanus*, slightly magnified, showing five workers engaged in the regurgitation of food to their comrades, and four winged queens. From a photograph by Mr. J. G. Hubbard and Dr. O. S. Strong.

A winged queen of *Camponotus americanus* regurgitated food to her deälated sister queen, on the twenty-fifth, the thirty-fifth, the fortieth and the sixty-second day of fasting, the visible transfer of food occupying several minutes.

The ants cannot, however, be considered to virtually possess a common stomach. There was great difference in the periods within which ants of the same colony and species, in the same cell, perished from deprivation of food.

The feeding of the larva by different ant-nurses doubtless conduces to its vigor, because the nurses forage in diverse localities bringing back nutriment containing unlike chemical elements which they transfer by regurgitation to the growing young.

Doubtless the adult ants also benefit greatly through the habit of regurgitating food to each other. Going afield in many directions, one finds nectar, another berries, another nut-kernels, another insect flesh, another egg-yolk, and many give of their garnered nutriment to their companions in the nest. Variety in the food supply for each individual is in fairly direct ratio to the number of fellow-workers who reach new sources of sustenance. Vigor gained by the adults through varied diet and the assimilation of new chemical compositions, would tend to increase the stamina of the growing young through an improved pabulum as well as through heredity.

There is notable difference in the average size and vigor of the individuals in different colonies of ants of the same species.

Relation of Sex and Food to Tenacity of Life.

Male ants shared all tests here presented, but whatever the test undergone, the males showed far less tenacity of life than did either the queens or the workers.

If, as has long been held, the product of unfertilized ant-eggs are males while the product of fertilized ant-eggs are females, then it may be that the absence of certain chemical elements contained in the fertilized egg is a cause of lesser tenacity of life in the male ants.

In all tests of vitality, ants of largest stature among their species showed greatest tenacity of life. Whether the test applied

were endurance of heat,[1] submergence in water, deprivation of food, excision of parts of the body, or administration of poison, the larger the ant, the more probable its survival.

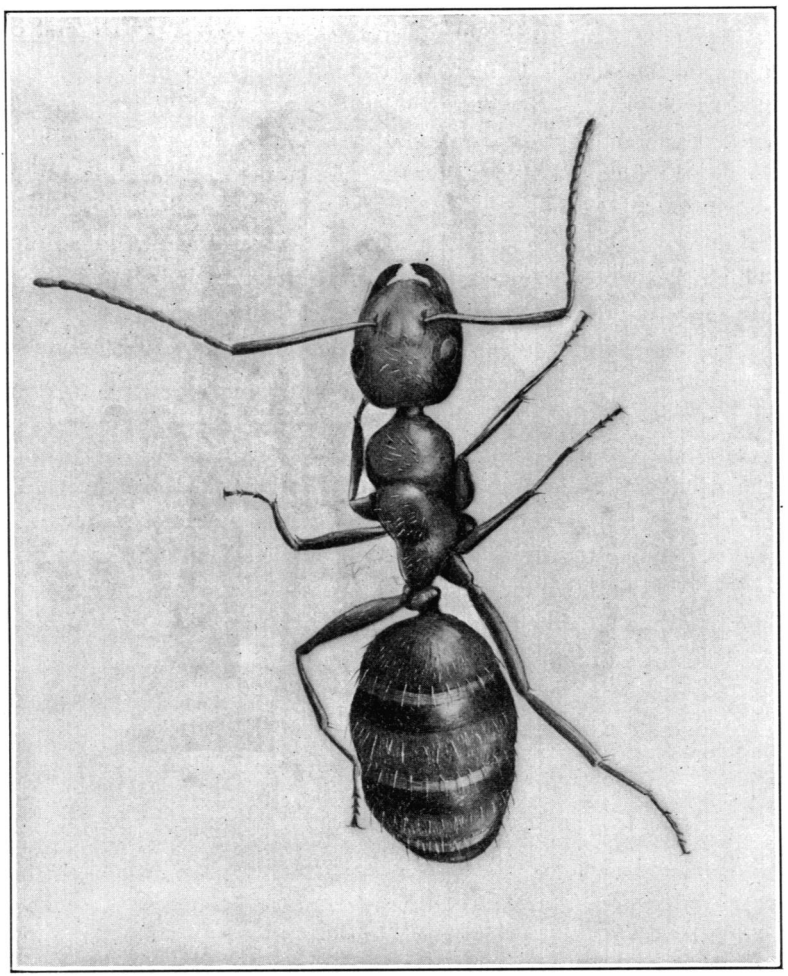

FIG. 1. *Camponotus pennsylvanicus* worker. × 6. From a photograph taken by Mr. J. G. Hubbard and Dr. O. S. Strong, and retouched by Dr. J. H. Macgregor.

There appears to be also a relation between size and natural longevity. Two hundred *Stenamma fulvum piceum* workers,

[1] See paper referred to in previous note, BIOLOGICAL BULLETIN, June, 1904.

majors, minors and minims, were segregated by me in August, 1901, and were kept under observation until August, 1904. At the end of the three years there were eleven survivors, and ten of these were of the largest stature attained by these ants, seven millimeters. Queens, whose longevity probably exceeds that of workers, are ordinarily of larger stature than they.

It has long been known that the size of an ant depends on the quantity and quality of nutriment taken while in the larval stage; but larval nutrition determines not only the size of the ant within the limits of its species; it also determines something of greater influence in the life of the individual and the persistence of the tribe, the probabilities of survival under adverse conditions.